Planning for resilience in urban transport.

Dr. Hector G. LOPEZ-RUIZ
Transport Economics Laboratory - National Center for Scientific Research
University of Lyon.
14, avenue Berthelot –F-69363 Lyon Cedex 07
hlopezruiz@gmail.com

Abstract: *This paper develops the idea of taking into account the systemic effects of public policies for sustainable transport in long-term scenarios. A comprehensive assessment of these effects is a particularly important factor in identifying potential unbalancing elements and planning for resilience to the effects of mitigation policies in view of increasing acceptance to different measures on which GHG reductions depend.*

Key-words: *Modelling, Greenhouse gas, Coupling, Scenarios, 2050 horizon, mitigation, adaptation, multimodality, decoupling.*

I. INTRODUCTION

In an effort to counteract global warming and lessen the geopolitical risks linked to energy supplies by decreasing oil intensity in economic activities, many countries have decided to limit their oil consumption and global greenhouse (GHG) emissions. This determination is requiring governments to make a choice between –the well-known- oil dependent growth path and the –rather unfamiliar- green growth path.

As with any economic change concerning energy supplies, uneasiness about cutting GHG emissions stem –in part- from the uncertainty concerning technological options for producing enough "zero-emission" energy in order to cover the world's demand. What is more, the prospect of having to change the way societies are organized in order to cut down on carbon-intensive behaviours is also causing unrest. Even though growing constraints on fossil-fuels are already curbing energy demand and modifying behaviour in some activities, nervousness around the fact that not all sectors of the economy are equally flexible and adaptive has surfaced.

In the transport sector, the undeniable suppleness and low costs of road transportation (for passengers and freight) has been a key element to its success over the last few decades and largely explains its increasing demand. This growth trend in mobility has been particularly vigorous in urban transport and has become an important issue in the debate on developing sustainable mobility.

The question of rising urban mobility and its inherent urban sprawl is often linked to, both, economic growth (ECHENIQUE, 2007) and high levels of GHG emissions. The idea of having to choose between growth and the environment has been one of the main debates in planning for the reduction of the climate change risk linked to human activities.

Recent scientific insight shows that in order to decrease the probability of overshooting a 2°C increase in global temperatures, GHG emissions should be cut by at least 50 % (from the 1990 level) in the next 40 years. Consequently, certain studies have implied that cutting down drastically on road transportation in industrialized countries and curbing road transport demand growth in newly industrialized countries will, inevitably, translate into an economic downturn.

In an effort to offer new and innovative solutions aiming at reducing emissions, numerous studies have analysed different courses of action and their implications on the transport sector. All of them conclude that although GHG mitigation will not be an easy task, it does not necessarily suppose shrinking economic activity. Indeed, different studies (BANISTER & HICKMAN; KATO & ITO *et al;* LOPEZ-RUIZ & CROZET; SCHADE & HELFRICH *et al*; SCHIPPER & NG *et al*; SPERLING & LUTSEY) have looked into several options on how to plan for these drastic reductions. These studies concur on the fact that new technologies and their widespread use will be necessary in order to attain considerable GHG reductions. Furthermore, they also agree that these new technologies will not be enough for countries to get to their GHG objectives. Indeed, most works conclude that GHG mitigation supposes careful planning in order to increase the match between "green" transport supply and consumer demand through the use of incentive economic instruments. Thus, they clearly underline that expected technological progress in the transport sector cannot be effective if it is not accompanied by deep organizational and behavioural changes.

Consequently, a growing body of research has developed interest on how public policies aiming at GHG mitigation will have an impact on socio-ecological systems. Along these lines, this paper will explore how a simple microeconomic model can help plan for resilience of the transport system in its quest for sustainability through a mix of behaviour change and new technologies.

In order to carry out our analysis we will refer to what is commonly accepted as the two main options for GHG mitigation through changes in behaviour: increasing the use of other transport modes (multimodality) or moving less (decoupling transport from GDP growth).

Both of these options suppose changes in how everyday mobility is carried out as well as important modifications in how people organize their lives. From an economic standpoint, the two main factors in which behaviour oriented policies have an impact are: time budgets and money budgets. Many authors have proposed different models referring to the relationship existing between the two, but, for the needs of this paper, we will be referring particularly to the LINDER (1970) model. This approach will enable us to give new insight on how planning for behavioural change in transport activities through time-intensiveness management can offer better adaptive capacity of the system to environmental constraints.

For this, we will propose a simple framework based on a time-value management approach that aims at exploring how policy analysis can be used to define long-term strategies based on time intensiveness. The main results will look into how both industrialized and newly industrialized economies face similar dilemmas when it comes to planning for long-term sustainability in transport activities.

II. THE ANALYTICAL FRAMEWORK

As planning for GHG mitigation goes forward, different studies have shown that, in the absence of new –revolutionary- motor technology, public policies aiming at deep behavioural changes will be necessary in order to curb GHG emissions. These changes imply increasing constraints on high carbon footprint mobility through economic and social incentives that could range from educational and awareness programs to tolling, rationing or even carbon taxing.

Because of their socio-economic characteristics, the wide array of public policies that can be carried out in order to curb GHG emissions are tightly linked to changes in current mobility practices. Consequently, although these changes in behaviour represent a viable solution for mitigation of GHG emissions, they could also lead to imbalances on a microeconomic level. What is more, these imbalances could turn into counterproductive socio-economic side effects that could stun overall acceptance of the policy’s objectives. As an answer to these preoccupations, an increasing body of work in social-ecological systems suggests the idea of planning for resilience (FOLKE, 2006) in order to increase a system’s adaptability and in consequence, policy acceptance.

This planning process implies understanding that the implementation of different long-term policy mixes entails a (re-)optimization of agents’ (passengers and firms) choices based on land-use and transport characteristics of a given territory. In other words, planning for resilience supposes a careful analysis of what different sustainable scenarios imply on welfare variations associated to trade-offs between transport expenditure; house/firm location; accessibility; transport money/time budgets and *in fine* consumption of goods/services.

Consequently, in order to define how acceptance of different public policies can be increased through planning we need to asses the type of (re)-optimizations at play. For this, we propose a simple microeconomic choice model that lets us understand how, according to past tendencies (characterized by the coupling between growth and mobility), future public policies will impact demand for transport services as well as trade-offs linked to behavioural change and infrastructure use on different geographical scales.

This model relies on the idea of a representative agent that optimizes her/his transport decisions by taking into account opportunity (defined as the sum of goods and services that can be consumed in a period of time, LINDER, 1970) and cost in respect to mode characteristics and infrastructure level of service (measured through a lateness index).

The model considers that the lateness index is defined by the difference existing between normal transit time and real transit time. This indicator is useful in factoring in speed, distance and time into the calculation of the choice model and has the convenience of being comparable between modes.

In this manner, the proposed framework allows us to assess the representative agent's choices that are coherent with the transport structure and its level of service. In the model, the value assigned to each choice is calculated using the following equations:

$$a(t) = \frac{[\tau\ (t)]^{\alpha}[\eta]^{\beta}}{\sum_{1 \in Ni}[\tau(t)]^{\alpha}[\eta\ ]^{\beta}} \qquad \forall j \in N_i$$

Equation 1

Where:

$$\eta\ = \frac{opportunities}{(time + accestime) * \cos t}$$

Equation 2

and

$$\tau(t) = Lateness\ index(t)$$

Equation 3

Using this microeconomic model, the inherent logic for technico-organizational public policy assessments is linked to the idea that: public policies are implemented as increasing/decreasing constraints on the overall system in view of getting to a certain objective (for example, a defined reduction in oil consumption or a certain level of GHG emissions). Consequently, this implies a wide variety of social effects on different levels and aspects that will modify the agent's decisions based on changes in transport prices, travel times, level of service, etc. These effects are translated into the model as changes in the opportunities and/or cost factors. Furthermore, the changes in the opportunity/cost structure are then linked to household budget (money and time) reallocation effects that will have an important impact on other sectors (which will also have a loopback effect on transport).

III. ADAPTING TO CHANGE

The inherent principle of most sustainable transport policies is based on: rendering high carbon footprint transport less attractive (through prices, modal speeds, infrastructure level of service, awareness courses, etc.) than low carbon footprint transport. This principle aims at modifying individual microeconomic behaviours in order to have an impact on the overall transport structure. Although these effects will be different for each country, network and set of public policies, certain basic general economic trade-offs are valid in most analysis.

In essence, rendering high carbon footprint transport less attractive suggests the need for constraints on emissions. These constraints come into play as a signal aiming at changing behaviour patterns in transport users. Consequently, the socio-economic system adapts through a sharp increase in the use of low carbon footprint modes.

As constraints on high emission modes kick in, potential unbalancing factors could come into play. Indeed, in the presented microeconomic model, policy aiming at developing strong multimodality in a system, translates into: paying more (especially for car users who would be unable to shift to public transport) for lower transport speeds (an all modes), thus higher transport times. This situation supposes a loss of potential value added time that could, otherwise, be spent increasing revenue.

In sum, a multimodal scenario is based on mixing: an increase in the cost of car use with lower speeds in public transport: $\eta = \frac{\text{opportunities}}{\Uparrow (time + accestime) * \Uparrow \cos t}$. This translates into a situation where an agent's cost structure grows as his set of opportunities would be –at best-stable. What is more, this situation could also represent a risk to poor households that could suffer a "choking effect" through this double logic of: increasing transport costs and diminishing opportunities (UBBELS & VERHOEF (2006)). Consequently, the question of the widespread acceptance of policies aiming to develop multimodality is raised.

If we follow the same line of reasoning, the logic behind a decoupling scenario is very influenced by proximity services. In this type of scenario, public policies at play are largely related to spatial planning and infrastructure investment. In a decoupling logic, the main trade-off at play is directly linked to location strategies and production organization aimed at decoupling transport distances from GDP growth. This entails a densification of main cities and production sites through the optimization of land use. In other words, the η ratio would increase costs but would leave access/transport times stable (or even decrease them) $\eta = \frac{\text{opportunities}}{(time + accestime) * \Uparrow \cos t}$.

In this manner, transport cost characteristics in a decoupling logic lead to more stable transport money and time budgets. This is explained by the rise in transport prices being followed by land use optimization. Nevertheless, if a decoupling scenario were not followed by an adaptation strategy based on a fast increase in the supply of proximity opportunities, an important loss of welfare could be observed. Indeed, what good is creating dense cities without putting opportunities inside them?

Through this analysis of policy effects on the transport system using a choice model we aim to show that the need to ensure a system's adaptability to change should be strongly linked to strategies looking to counterbalance undesirable effects. In this manner, the idea of increasing opportunities linked to transport activities should become a part of the sustainability planning agenda.

This translates into the need for an optimization of land use based on PHELPS's and BAUMOL's view of the Linder theorem. In their 1973 papers, they comment their views on time and consider that money does not buy time but it can buy time-intensiveness and thus, more opportunities. Paradoxically, the LINDER-PHELPS-BAUMOL analysis has been used for a long time in order to explain how, over the decades, society has increased time-intensiveness through access to speedier transport.

Nevertheless the Internet has showed us that it is not only physical speed that counts but rather the speed in which we can access opportunities. This suggests that the key element in sustainable transport planning lies in increasing the sum of goods and services (opportunities) linked to the accessibility offered by transport. Through this, the equilibrium in the η ratio is ensured as well as the system's resilience to environmental constraints.

Moreover, the need to adapt to the effects of mitigation policies does not only relate to an unbalanced η factor. This need is reinforced by the fact that as constraints on oil consumption grow, more and more passengers will turn to public transport services. Consequently, a second factor that explains the need for planning for resilience is: a shift in market power.

As private vehicle costs rise, public transport use will also rise and, in consequence, this will imply a decrease in the price elasticity of demand of public transportation and thus cause a shift in market power. This change in market power should most undoubtedly profit users instead of transport operators. Consequently, this reinforces the idea that the system should be pushed towards a change in how access to opportunities is conceived by operators and planners.

Currently, certain dense networks are already starting to carry out this type of analysis, for example the Access To Opportunities and Services (ATOS) index (COOPER, S. WRIGHT, P. & BALL, R, 2009) proposed by Transport for London in order to improve planning measures.

Indeed, just as the UK's planners have begun changing their metrics in order to take into account these new behaviour patterns in transport activities, ITS specialist and planners should seize the opportunity to develop and offer new services. This implies the need to explore new markets that will be based on an economic model taking into account adaptation strategies that conceive the utility of transport users as not only as being a function of opportunities but also of the goods and services that are accessible to them in a reasonable lapse of time (GEURS, 2004). This supports the idea of accompanying changes in the time/cost structure of transport budgets that aim at modifying behaviour with increasing opportunities linked to transport activities and land use patterns :

$$\eta = \frac{\Uparrow \text{opportunities}}{\Downarrow (time + accestime) * \Uparrow \cos t}.$$

IV. CONCLUDING REMARKS

As public policy evolves, changes in the transport system will suppose behavioural modifications. This situation will face planners and industry deciders with a new challenge: to plan according to a utility function that will not only depend on the opportunities a transport user has but also on the possibility of actually being able to access and consume these opportunities. Indeed, as the transport cost/location structure changes, new trade-offs and optimizations will redefine time use. These changes will have important impacts on the overall macroeconomic structure of a country and will have important effects on the microeconomic choices of transport users. In this sense, sustainable policy planning should be accompanied by adaptation strategies.

Just as transport planning, until now, has built the current transport system around the idea of increasing access to speed (urban motorways, airplanes, high speed rail) in order to gain access to new opportunities (ECHENIQUE, 2007 & SCHEAFFER, 2009), environmental constraints imply the need to plan for an increase in accessibility without raising speed.

In 1973, BAUMOL, based on LINDER’s work, concluded that as productivity grows, free time is pushed towards an increase in the intensity of activities accomplished in a person’s free time and goes on to explain that as this happen, time consuming activities will tend to disappear (going to the theatre, or even luxury cruises). In the same year, PHELPS describes consumers as: “a one-man, Mincer-Becker-Lancaster factory” and views commodities as “unfinished materials that need to be combined with the factory’s at-home labour time (and sometimes consumer durables) to produce final utility”

Although these ideas are nothing new, they seem to be perfectly adapted to what DUJARIER describes as the “next limit of competitiveness”. Through this, she explains how firms have faced rising production costs by getting buyers to become co-producers who render their free time productive by creating value whilst participating in the production process of the goods they buy and consume (be it by sheer interest in the activity, because it helps reduce prices or even make-up for forgone earnings in free time).

Just as with any other product, the next limit of transport competitiveness lies in the ability to face rising environmental constraints by increasing the “at-transport time” and the “access-time” value-intensiveness through time-value management strategies as well as land-use optimization. Although these changes will be difficult for industrialized countries that have built their networks around speed, this seems to be an ideal opportunity for newly industrialized economies to use their already high level of public transport in order to develop new adaptive strategies.

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